# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL TECHNOLOGY (36)
## PHYSICAL CERAMICS
## SUBJECT CODE: 2183606
## B.E. 8TH SEMESTER

**Type of course:** Chemical Technology

**Prerequisite:** The students should have a clear concept on basic chemistry, geology and Mineralogy that will help them to have an easy grasp of the subject and GC08.

**Rationale:** The main objective of this subject is to offer an overview over the fundamentals and basics of materials science, engineering materials, phase diagram, microstructure & characterization, various properties of engineering materials.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Theory Marks | | | Practical Marks | | | |
| | | | | ESE (E) | PA (M) | | ESE (V) | | PA (I) | |
| | | | | | PA | ALA | ESE | OEP | | |
| 4 | 0 | 3 | 7 | 70 | 20 | 10 | 20 | 10 | 20 | 150 |

**Content:**

| Sr. No. | Topic | Teaching Hours | Module Weightage (%) |
|---|---|---|---|
| 1 | **Ceramic crystal structures** : Corrundum , Wurtzite , Zinc blende , Rocksalt , Perovskite and Spinel structure etc.; Atomic Mobility : Diffusion & Diffusivity, Laws of Diffusion , Diffusion in solids , Controlling diffusivity . Nernst-Eistein equation. Temperature & impurity dependence of diffusion. Diffusion in crystalline oxides. Dislocation. Boundary & surface diffusion | 10 | 16 |
| 2 | **Phase Transformations** : Formal theory of transformation kinetics with examples.<br>Spinodal decomposition. Thermodynamics & kinetics of nucleation & growth.<br>d) Grain Growth, Sintering & Vitrification : Sintering - Single & multiphase . Study of sintering - Kinetics , mechanisms of mass transport , Sintering variables , Sintering aids .Recrystallisation & grain growth. Abnormal grain growth. Sintering vis-à-vis Vitrification. Sintering with a reactive liquid. Pressure sintering & hot pressing. Secondary phenomena. Firing shrinkage. | 10 | 16 |
| 3 | **Microstructure & Characterisation**: Features in microstructures. Microstructural observations - Optical & Electron Microscopy. Techniques of sample preparation.<br>Ceramic Phase Equilibrium Diagrams: Techniques of determining | | |

| | | | |
|---|---|---|---|
| | phase diagrams. One - , two - , and three - components phase diagrams. Examples. Phase composition versus temperature. Non-equilibrium phases. Typical ceramic systems like<br>zirconia - calcium oxide / magnesium oxide / ceria , calcia - silica , magnesia - silica ,soda - lime - silica , lime - alumina - silica etc. | 10 | 16 |
| 4 | **Electrical Properties** : Electrical conduction in materials, Electron mobility, Drift velocity, Relaxation time, Electrical resistivity, Energy band model : Insulators, Conductors, Semiconductors diagrams, Mechanism of electrical conduction in intrinsic and extrinsic semiconductors, Charge transport in pure silicon, Quantitative relationship of electrical conduction in intrinsic elemental semiconductors, Effect of temperature on intrinsic semiconductors, N - type and P - type semiconductors, Doping. Mass action law, Charge densities in intrinsic semiconductors. Electronic & Ionic conduction, Ceramic conductors like varistors, thermistors, resistors etc. Piezoelectricity, Ferroelectricity. | 10 | 17 |
| 5 | **Magnetic Properties** : Diamagnetism , Paramagnetism , Pauli paramagnetism , Ferromagnetism , Antiferromagnetism & Ferri magnetism - Ferrites .Soft & Hard magnetic materials- Ferrites, Mixed ferrites, Origin of interactions in ferro - and antiferro<br>- and antiferri - magnetic materials ---> direct, super and double exchange interactions. Exchange energy, Magnetostatic energy, Magnetocrystalline anisotropy energy, Domain wall energy, Magnetostrictive energy.Properties & applications of ferrites. | 10 | 19 |
| 6 | **Optical Properties** : Introduction. Light & electromagnetic spectrum, Electromagnetic<br>waves in ceramics, Refractive index, Dispersion, Reflection and refraction. Transmission & reflection of light. Luminescence : Photo & Cathodes. Lasing action | 10 | 16 |

**Suggested Specification table with Marks (Theory):**

| **Distribution of Theory Marks** | | | | | |
|---|---|---|---|---|---|
| R Level | U Level | A Level | N Level | E Level | C Level |
| **21** | **37** | **23** | **9.5** | **9.5** | **-** |

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

**Reference Books :**


1. Introduction to Ceramics - W.D.Kingery
2. Fundamentals of Ceramics - Barsoum
3. Physical Ceramics for Engineers - Van Vlack
4. Principles of Materials Science & Engineering -Smith
5. Handbook of Ceramics - Editor S. Kumar


**Course Outcome:** After learning the course the students should be able:

1. To express their technical knowledge over fundamentals of the subject
2. To be able to utilize their knowledge and skills for the preparation of other related highly technical subjects in the Glass & Ceramic Technology course curriculum
3. To be able to apply this knowledge in their higher study, research work with related technical subjects.
4. To build a bridge between theoretical and practical concept used in industry.

**List of Experiments:**

| | |
|---|---|
| 1. | Study of different crystal structures of different ceramic materials |
| 2. | Study of recrystallisation in alumina bodies |
| 3 | Study of grain growth in alumina ceramics |
| 4. | Study of abnormal grain growth in ceramic materials |
| 5. | Preparation of samples for scanning electron microscopy |
| 6. | Study of electrical properties of ceramic materials |
| 7. | Study of magnetic properties of ceramic materials |
| 8. | Study of optical properties of ceramic materials |

**Open Ended Project fields:**

**Students are free to select any area of science and technology** based on chemical technology applications to define Projects.

**Some suggested projects are listed below**:

1. Industrial practices for diffusion in solids
2. Industrial practices for sintering processes
3. Industrial practices for testing microscopy
4. Industrial practices for studying ferroelectric behavior

**List of Open Source Software/learning website**:

1. Literature available on internet
2. Glass & Ceramic dictionaries
3. Delnet
4. Literature available under R&D in Ceramic & Glass industry.
5. Ceramic & Glass journals

**ACTIVE LEARNING ASSIGNMENTS**: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide.